DYNAMICAL BEHAVIOR OF DISTRIBUTED BIOCHEMICAL SYSTEM (GLYCOLYSIS)

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Glycolysis plays a central role for the energy metabolism of almost all living organisms. Generation and propagation of glycolytic waves has been demonstrated in a yeast extract under batch conditions [1]. In these studies has been shown, that the waves often start to propagate from the border of the medium to its center and can change direction during experiment. In order to understand this behavior in more detail, the simple distributed Selkov's model [2] was considered and the results of model were compared with experimental data.

The model, described the phosphofructokinase reaction, consists of two partial differential equations.

$$\frac{\partial x}{\partial \tau} = v - xy^2 + D_1 \frac{\partial^2 x}{\partial r^2}, \quad \frac{\partial y}{\partial \tau} = xy^2 - wy + D_2 \frac{\partial^2 y}{\partial r^2}. \qquad (1)$$

The model of the glycolytic reaction was considered in one-dimension closed tube. The boundary conditions were zero fluxes of metabolites x (substrate-inhibitor) and y (product-activator) at the tube ends. Linear stability analysis of the system (1) was used to characterize parameters regions of different possible dynamical in space, such as dissipative structures, waves.

In order to study phase waves in experiment we assumed spatial distribution of model parameter v that describe the influx of substrate. The phase waves in model were obtained and period, velocity and phase shift of the waves has been estimated and compared these data with experimental. It was shown that at certain range of v distribution the wave can change direction. A possible mechanism for this change of wave direction is discussed.

References

1. Bagyan S., Mair T., Dulos E., Boissonade J., Kepper F., Muller S.C..Glycolytic oscillations and waves in open spatial reactor: Impact of feedback regulation of phosphofructokinase.// Biophysical Chemistry. 2005. Vol. 116. Pp. 67-76.
2. Sel'kov E.E.. Self-oscillations in glycolysis. A simple kinetic model. // Eur J. Biochem. 1968. Vol. 4. Pp. 79-86.